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Ultra-Sensitive Photonic Crystal Fiber Based Refractive Index Sensor for Efficient Alcohol Detection

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INTRODUCTION & AIM

This study presents a highly sensitive photonic crystal fiber (PCF) sensor for alcohol detection at 850 nm. The sensor is designed to optimize light-matter interaction, providing high sensitivity and low confinement loss for various alcohols like methanol, ethanol, and pentanol. The purpose is to improve detection precision for industrial quality control, medical diagnostics, and environmental monitoring.

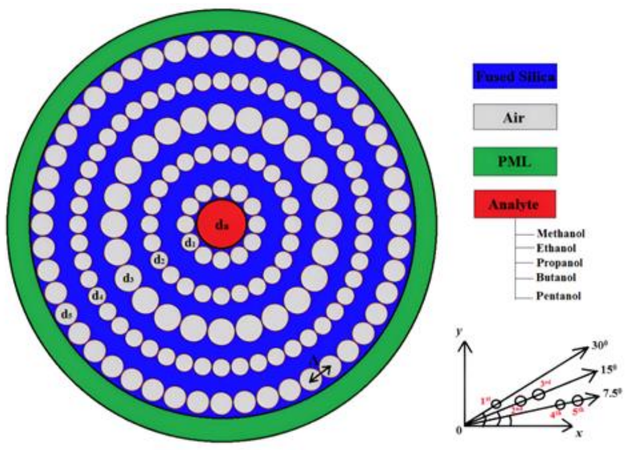

Figure 1. Cross sectional view of the proposed MC-PCF refractive index sensor.

METHOD

The sensor was designed using FEM simulations in COMSOL Multiphysics, optimizing the geometric parameters of the modified circular photonic crystal fiber (MC-PCF). It detects alcohol by utilizing variations in refractive index, achieving superior sensitivity with minimal signal loss.

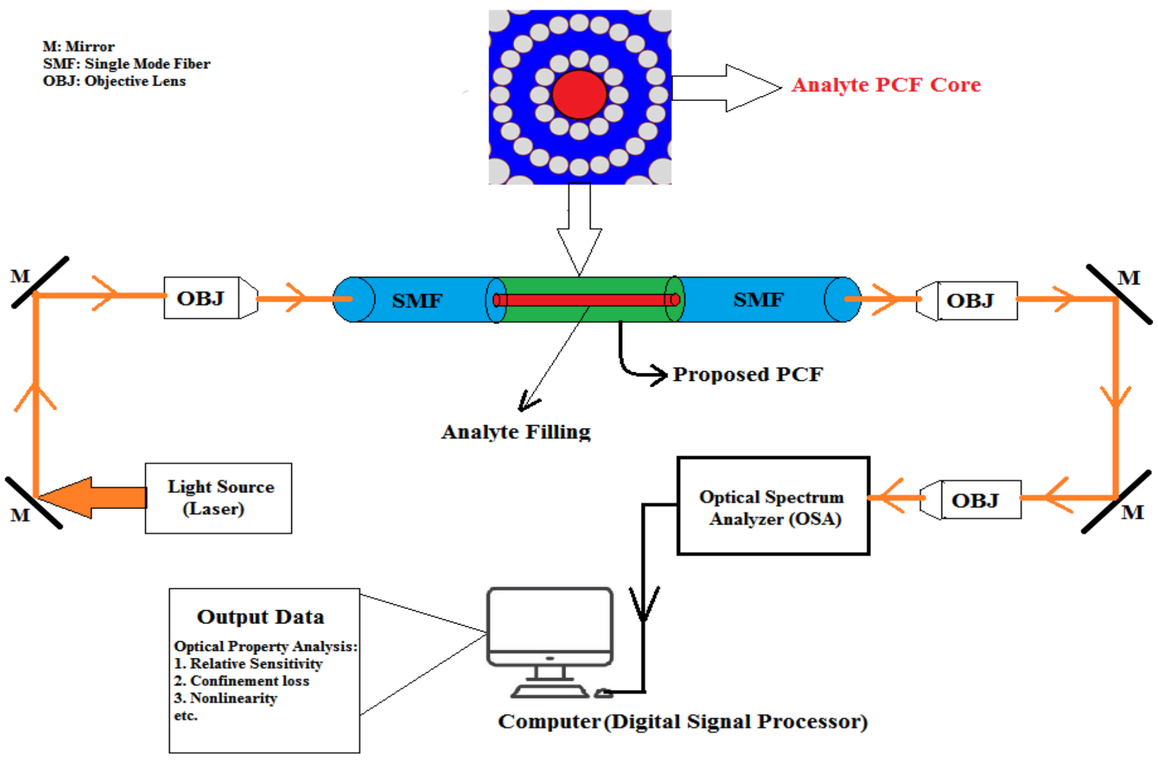

Figure 2. Schematic representation of proposed MC-PCF refractive index sensor integrated photochemistry setup.

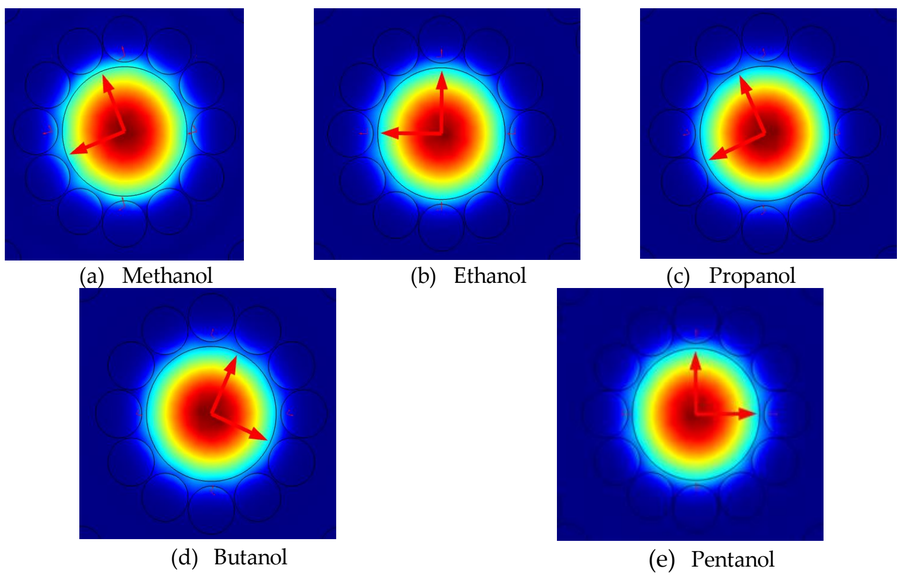

Figure 3. Electromagnetic field distribution for different alcohol analytes.

RESULTS & DISCUSSION

Relative Sensitivity:
Methanol: 95.51%
Ethanol: 97.2%
Propanol: 97.85%
Butanol: 98.69%
Pentanol: 99.4%

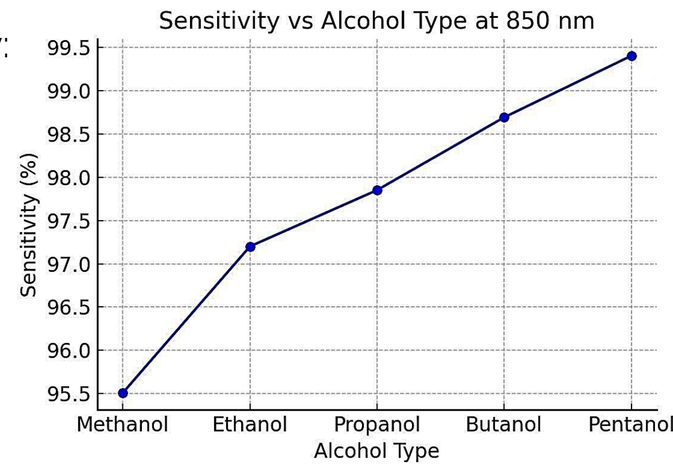

Figure 4. Plot of Sensitivity vs. Alcohol Type at 850 nm

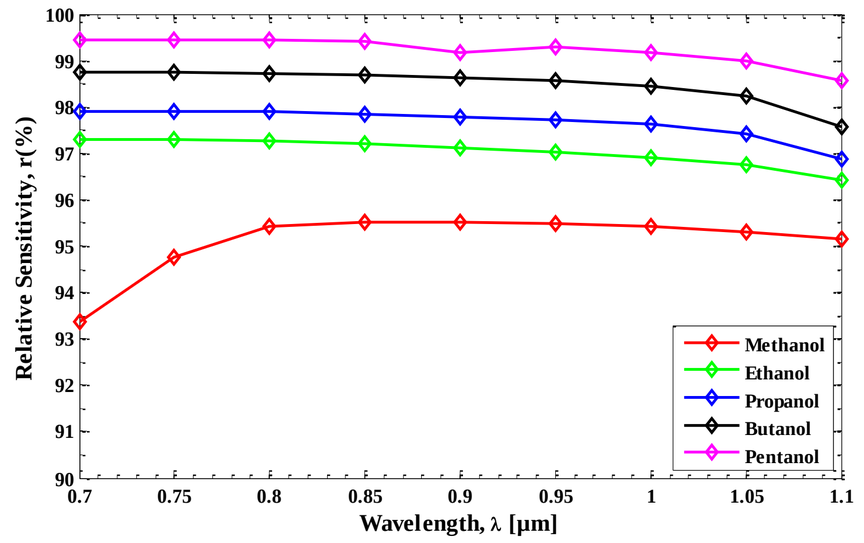

Figure 5. Wavelength-dependent relative sensitivity curve for different alcohol analytes using the MC-PCF sensor.

The sensor demonstrated extremely low confinement losses, enhancing its performance in detecting different alcohol types.

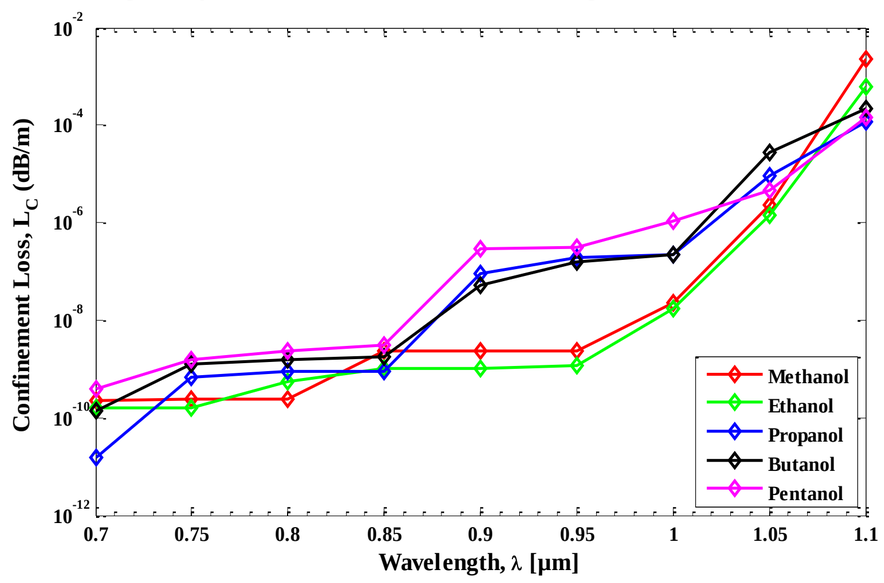

Figure 6. Wavelength versus Confinement loss curve for different alcohol analytes.

CONCLUSION

The MC-PCF sensor showed exceptional sensitivity across various alcohols with minimal signal loss, making it highly effective for real-time alcohol detection in industrial, medical, and environmental applications. It offers a reliable solution with up to 99.4% sensitivity for pentanol.

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